INDUSTRIAL ASSESSMENT CENTER PROGRAM
Final Technical Report

PERIOD: SEPTEMBER 1, 2002 TO AUGUST 31, 2006
AWARD NUMBER: DE-FC36-02GO12095
CENTER LOCATION: Bradley University
DIRECTOR NAME: Dr. D. Paul Mehta

Executive Summary

The Industrial Assessment Center at Bradley University (BU IAC) has been successful in promoting the wise use of energy resources, reduction of environmental waste and increased productivity in the industrial sector. Over 1100 assessment recommendations have been made to 94 industrial clients from September 1, 2002 to August 31, 2006. The projected savings from these recommendations exceeded $15.5 million of which just under $10 million or 62% were implemented. In addition to this over 50 students have been trained to identify opportunities to reduce costs in industrial facilities. Many of these students have gone on to careers where they influence the costs of manufacturing thus multiplying the efforts of the center. The details of how this was accomplished is contained in the report which follows.

TASK 1: Conduct Industrial Assessments, to include a variety of plant types and sizes as well as coverage of the geographic area defined in the Annual Workplan.

Out of the over 1100 assessment recommendations Figure 1 shows how many were identified in each of the three primary categories of energy, waste and productivity. Figure 2 shows the breakdown of the 564 recommendations which were implemented.

Figure 1. Number of Recommendations 2002-06

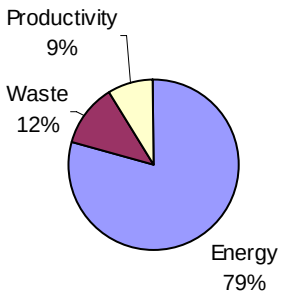
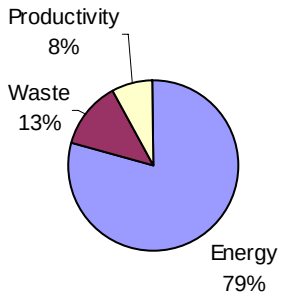


Figure 2. Number of Recommendations Implemented 2002-06



Out of the over $15.5 million in assessment recommendations Figure 3 shows how many were identified in each of the three primary categories of energy, waste and productivity. Figure 4 shows the breakdown of the just under $10 million in recommendations which were implemented.

Figure 3. Value of Recommendations 2002-06

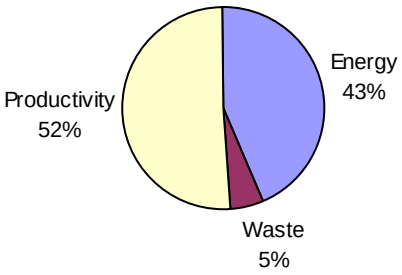


Figure 4. Value of Recommendations Implemented 2002-06

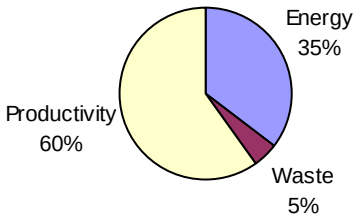
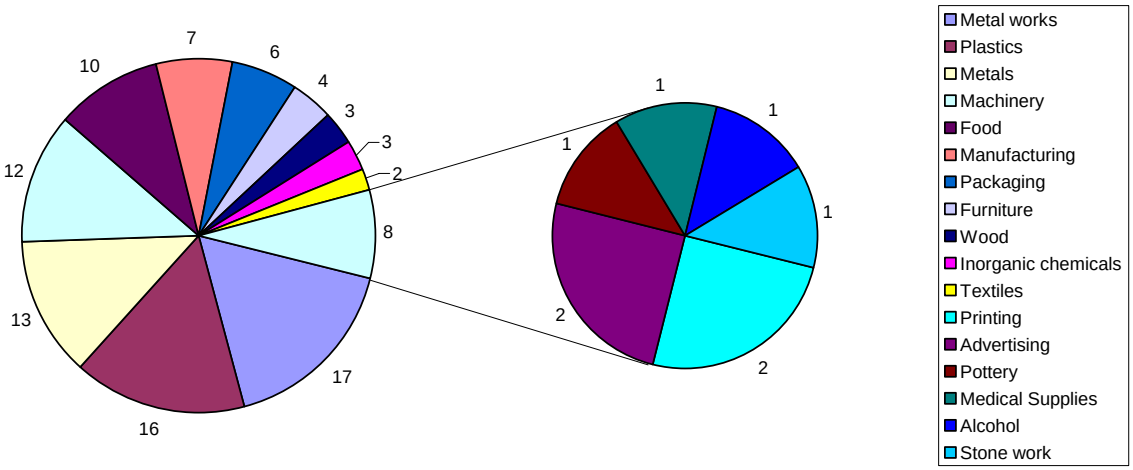
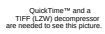


TABLE 1

The types of industries that were assessed are summarized in Figure 5. For each type of industry the number of assessments that were conducted are indicated in the figure. Metal works was the industry that took advantage of Bradley University's Industrial Assessment Center's services most with 17 assessments. Metal works (SIC 3400,s) include doors, sheet metal, buildings, fasteners, forgings, stampings, pipes and fittings.

Figure 5. Assessments by Industry

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are needed to see this picture.

TASK 2: Promote and increase the adoption of assessment recommendations

The Industrial Assessment Center at Bradley University has been quite proactive in promoting and increasing the adoption of assessment recommendations. The primary key to this has been hiring a talented Business Specialist who was persistent in obtaining implementation reports as well as searching for the root causes of why clients implement the recommendations in the reports. One of the key causes was to customize the report to the client. Often as we listened to the client we would become aware of unique opportunities that we not addressed in the typical recommendations. Additionally several different forms of communication techniques were tried ranging from including the client in the brainstorming session to telephone follow-up for the implementation report. The details of our initiatives are presented in the following bullets.

- 50 new assessment recommendations were developed. These new recommendations were developed to address specific client needs that were identified during the industrial assessment.
- 89 Implementation Reports were uploaded this during this period by the Project Business Manager.
- On September 6, 2002 a search for a Business Specialist was initiated. Advertisements for the position produced five applicants three of which were highly qualified for the position. After a rigorous interview process the position was offered and accepted by Seyedah (Ellie) Najafi. Ms. Najafi is an excellent addition to the staff of Bradley's center because of her excellent communication, and interpersonal relationship skills
- In the case of providing external financial resources for manufacturers, we investigated the possible opportunities where manufacturers will be able to lease certain recommended equipment (e.g. lights) rather than purchasing them. This will cause less financial debt impact on the companies which is initially one of the reasons that manufacturers seem to not to implement out assessment recommendations.
- In addition to our traditional follow up for implementation result (Mailing), we are doing phone call interview with our clients. The results have proven very effective. In one case the implementation rate improved by 65% from a rate of 26% to 43% because of the telephone follow-up.
- Our communication with our clients has been significantly improved and this has had a positive impact on our assessment performance and implementation feedback. The approach we have been taking is to include the client in the brainstorming session. Clients are more receptive when they feel that they are the main player of the whole process, they voluntarily communicate with us, they have been given us some alternative ideas for some of our identified recommendations. These all will help to accomplish goals of IAC, such as improving the manufacturers' sensitivity towards energy conservation, improving the quality of our service, enhancing students' knowledge towards energy conservations solutions and etc.
- The project manager spent 10 minutes at the beginning interview during the site visit presenting a motivational speech, which gave incentives to manufacturers to take actions on our recommendations.
- The Project Business Manager taught a course in the business school. She has had external speakers present the following two topics to the students: "Energy Efficiency" and "Sustainability and Life Cycle Management." These future business leaders will be more sensitive to making effective decisions in the future as a result of this exposure

TASK 3: Promote the IAC Program and enhance recruitment efforts for new clients and

expanded geographic coverage

The Project Business Manager was a key to the Center's success in recruiting new clients. Prior techniques for recruiting clients were not effective. Once the center hired someone with the necessary marketing skills there was no problem in finding clients. Not only were there a sufficient quantity of clients the quality of the clients improved as well. Many were motivated to provide us the data needed to quantify the cost and savings of the recommendations in the report.

- 94 companies were recruited in this period by the Project Business Manager.
- Clients in Missouri and Indiana have been served by the Bradley University IAC in this period.
- The Business Specialist has developed a preliminary business and marketing plan with an aim to improve the implementation rate of assessment recommendations.
- The Business Specialist did an outstanding job recruiting new clients that are motivated to participate in the assessment. The clients have been responsive in providing the information that is needed to perform a complete assessment of their energy, waste and productivity. The Business Specialist has done this using the field trip approach to recruiting clients

TASK 4: Provide educational opportunities, training, and other related activities for IAC students

The Industrial Assessment Center at Bradley University provided many opportunities for over 430 students to learn about energy, waste and productivity. The director and one of the assistant directors taught six different courses where the principles for the design of thermal systems were presented to the students. In addition, seven custom seminars were provided to Bradley University students to expand their understanding of energy, waste and productivity.

- The director taught 11 courses entitled "Thermodynamics" where 86 students were trained to apply the conservation of energy to pumps, compressors, turbines, nozzles, diffusers, motors, valves and heat exchangers.
- The director taught the course entitled "Energy Management" 5 times over this period where 72 students were trained to conduct industrial assessments.
- The director taught the course entitled "Industrial Pollution Prevention," 5 times over this period where 67 students were trained to conduct industrial assessments.
- One of the assistant directors taught 4 courses entitled "Thermodynamics" in this period where 120 students were trained to apply the conservation of energy to pumps, compressors, turbines, nozzles, diffusers, motors, valves and heat exchangers.
- 29 students were trained on air conditioning system performance in our Mechanical Systems Laboratory. The air conditioning trainer was made possible through funding provided by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE). This funding was secured by one of the assistant directors of the IAC.
- Five seminars were developed and conducted, each 2 hours long covering: Basic Energy, Instrumentation, Basic Lighting, Boilers, & Compressors. These seminars improved IAC student's hands-on application knowledge, use of audit instrumentation, and identification of Assessment Recommendations.
- Dr. Max Wessler (Emeritus Professor of Mechanical Engineering) met with BU IAC employees individually on at least 50 occasions to assist them in their communication skills.
- A new course was added in the Fall of 2003 by one of the Assistant Directors entitled "Thermoeconomics." This course integrates thermodynamics, fluid dynamics, heat transfer and engineering economics in order to provide mechanical engineering students

with the tools they need to design energy systems. These tools are helpful for the energy engineer as they perform an industrial assessment.

- Video tapes on safety were made available to the student engineers to deepen their appreciation for eye, ear and fire safety.
- One of the assistant directors gave a seminar on safety for six IAC employees on June 23, 2004. The topics of eye and ear protection were covered along with fire, electrical and ladder safety.
- Four IAC student engineers attended the "Steam End User Training" in Chicago on June 8, 2004.
- One of the Assistant Directors is the Faculty Advisor for ASHRAE. The local chapter of ASHRAE sponsored a program entitled "Refrigeration Component Selection for Low Temperature Applications." This program provided information on thermal expansion valves and was made available in East Peoria for our student engineers to attend.
- One of the assistant directors taught students how to optimize the design of air conditioning systems using life cycle costs. There were twenty nine students in the class. Each of the students developed their own software to determine the optimum evaporator and condenser areas and isentropic efficiency of the compressor.
- The Department of Mechanical Engineering purchased a training apparatus of a Rankine cycle. This apparatus will be used in energy related courses taught by the director and assistant director to assist students in understanding how steam can be used to produce electricity. It is an excellent tool to help students make the connection between the textbook and actual hardware.
- One of the assistant directors trained fifty seven (57) students how to design pump and pipe systems to minimize life cycle costs. The students then tested their designs at the end of the semester on an apparatus that collected all the energy, flow, temperature and pressure data they needed to validate their design.

TASK 5: Coordinate and integrate Center activities with other Center and IAC Program activities, DOE's Industrial Technologies programs and others.

The director has faithfully attended all the director's meetings and has received and communicated valuable insights for making an IAC successful. This is evident in the many presentations and publications that he and his students have performed. The director and assistant director have been intentional on training students on the useful programs provided by DOE's Industrial Technologies.

- The Director trained his students on the use and applications of the following Best Practices Tools: PHAST and MotorMaster.
- One of the Assistant Directors is a Steam Specialist who trained students in the use of the Steam System Assessment Tool (SSAT).
- The Business Specialist submitted two articles, Ellie's Corner, to assist other centers with their efforts to recruit clients.
- Both the Director and Assistant Director attended a forum in December 2003 on combined heat and power (CHP) at the University of Illinois at Chicago.
- The assistant director found and forwarded information about two clients to the Midwest CHP Application Center. These clients were promising candidates for CHP based on their spark spread.
- The Assistant Director participated in the Midwest CHP Roadmap Workshop on March 16-17, 2004 in Chicago, IL. This workshop was sponsored by the U.S. Department of Energy-Chicago Regional Office.
- Four IAC student engineers along with the Director, Assistant Director, Project Manager

and staff engineer attended the "Compressed Air, Motors and Process Heating Workshop" in Peoria on September 14, 2004. This Workshop was sponsored by the US DOE Regional Office.

- The director and Project Manager attended a three day workshop on February 23, 2005 to February 25, 2005 on one-2-five/E-Achiever with the Department of Commerce and Economy Opportunities of the State of Illinois in Chicago.
- The Project Manager recommended to Michaela Martin to arrange a visit for a student named Mike Heidari to attend the student forum in Washington D.C. He made a presentation at the forum about the impact of Unique Recommendations on Implementation Rate. The presentation was well received.
- The Project Manager, Director and Assistant Director published a paper entitled, "An Analysis of Data at an Industrial Assessment Center for Improving Energy Efficiency." This was submitted on May 17th and was approved by ACEEE for presentation in July.
- The Assistant Director attended along with three students a technical symposium entitled, "Green Buildings and Energy Conservation." This symposium was sponsored by the American Society of Heating, Air Conditioning and Refrigeration Engineers. It was led by internationally known experts in the field and generated three continuing education/professional development hours for each of the attendees.
- The American Society of Heating, Ventilating and Air Conditioning Engineers approved funding for a senior project next year to design a heat exchanger and pump system design project for the Mechanical Systems Laboratory Course.
- One of the Student Engineers from Bradley University presented a speech entitled "The Story, the Opportunity and the Success for an IAC Engineer" at the IAC seminar in February 2006.
- The Director and one of the Assistant Directors submitted a proposal to the Oak Ridge National Laboratory (ORNL) entitled "Implementation of Energy Savings Assessments". The purpose of the proposal was to conduct up to fifteen Energy Savings Assessments for large industrial companies. Performing both process heating and steam assessments using PHAST and SSAT. The PHAST portion of the proposal was accepted.

TASK 6: Other tasks or special projects, as needed, and as determined by DOE to be advantageous to the program and in furtherance of IAC Program goals.

The IAC at Bradley University has been a springboard for many other creative projects that enhance the thermal science education of the next generation of mechanical engineers. These range for externally funded (industry and professional associations) energy-related research projects, lab apparatus development, seminars and continuing education for the staff of the IAC. Collaborations with other organizations that have similar goals to the IAC has also been a priority.

- One of the assistant directors was awarded a contract for over $100,000 to study the factors that contribute to nucleate boiling. The results of this work will produce a design guide to predict the onset of nucleate boiling. This design guide can then be used by boiler designers to optimize the design of steam generators.
- The Save Energy Now Program is being promoted by the Project Business Manager to the clients who are a part of the BU IAC network.
- The director is supervising a senior design team which is evaluating refrigerants based on their impact on the environment.
- One of the assistant directors is supervising a senior design team who is constructing an apparatus that will validate the optimum design of a heat exchanger based on life cycle

costs. The apparatus has three different heat exchanger sizes and three different pumps. This apparatus will be used in a lab for juniors in subsequent semesters.

- The Director attended and successfully completed training to become a specialist for heating equipment.
- The Assistant Director attended and successfully completed training to become a specialist for steam systems.
- Several modifications to the report format improved readability for the client.
- Dr. David Carter from Argonne National Labs gave a public lecture entitled, "The Hydrogen and Fuel Cell Economy." This talk was organized by one of the assistant directors. The lecture was attended by 57 people. Also, during the course of his two-day visit small group meetings were conducted with the Illinois Manufacturing Extension Center, Bradley's Biology, Electrical Engineering, Mechanical Engineering and Physics Departments, the staff of the Industrial Assessment Center, student members of the American Society of Heating, Ventilating and Air Conditioning Engineers, the Industrial Pollution Prevention class, a team of engineers developing fuel cells for Caterpillar Incorporated, the vice president of gas operations from Ameren CILCO and the director of Heartland Illinois Technology Enterprise Center.
- The final report for the special project entitled "Implementation Rate Analysis and Corrective Actions" was submitted on October 15, 2004. Three copies were sent to DOE and Rutgers. The final report contains the corrective actions which were identified based on detailed data analysis of BU IAC and the feed back obtained from a survey sent to clients.
- During conversation with Christopher Russell from the Alliance to Save Energy we talked about the project entitled "Implementation Analysis and Corrective Actions" and he suggested that if we could personally present it to him. In December 2004, we were able to meet with him and discuss the report. This was a valuable exchange since Christopher is responsible for a project funded by the Department of Energy to create a software program that will predict whether or not a prospective client will participate in an energy assessment.
- The director presented papers entitled "Optimization of Heat Treatment of Machinery Components" and "High Temperature Heat Recovery Through Waste Heat Boilers" in September 2005. The first publication was based upon the applications of PHAST to Heat Treatment Processes at Caterpillar.
- One of the assistant directors developed a semi-theoretical model of an evaporator for air conditioning systems. This model is an important first step in providing designers/manufacturers of air conditioning systems with a tool to optimize the design of air conditioners.
- One of the Assistant Directors had a paper accepted entitled "Deductive Problem Solving Strategy Applied to the Optimization of Wall Insulation."
- One of the Assistant Directors developed a system model for air conditioning systems. This model is an important tool to optimize the design of air conditioners. It uses life-cycle costs to determine the optimum heat transfer surface areas of the evaporator and condenser as well as the optimum efficiency of the compressor.

Other Achievements/Overall Status of Program.

The progress during the period has been strong at Bradley's Industrial Assessment Center. The center exceeded its goals in several areas.

Please complete the following table regarding IAC Program Expenditures

	IAC Program Expenditures		
Object Class Categories	**Budgeted**	**Costs Incurred to Date***	**Remaining**
a. Personnel			0.00
b. Fringe Benefits			0.00
c. Travel			0.00
d. Equipment			0.00
e. Supplies			0.00
f. Contractual			0.00
g. Construction			0.00
h. Other			0.00
I. Total Direct Charges	0.00	0.00	0.00
j. Indirect Charges			0.00
k. TOTALS	0.00	0.00	0.00

*** Please provide information on costs incurred through the end of the Quarter covered by this report.**

Supporting narrative/explanation: